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ABSTRACT

Reported is a study of the effects of self-pacing versus deadlines and working with a partner versus working alone on learning rate, retention, and attitude. Seventh grade Intermediate Science Curriculum Studies (ISCS) students of 12 teachers located in two different localities (city and county) participated in the study. Results showed that self-pacing produced higher learning rates and retention scores than did deadlines. This was particularly true for low ability children. The effect of working with a partner was different when measuring learning rate and retention, and was different for county and city children. There appeared to be an advantage for low ability children who had deadline in working with partners. These children performed significantly higher on the retention test than did low ability children with deadlines who worked alone. (Author/EB)

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The Effects of Pairing and Pacing on Learning Rate in ISCS Classrooms

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Synopsis

The effects of self-pacing versus deadlines and working with a partner versus working alone on learning rate, retention, and attitude were examined through analyses of variance. Data were analyzed for seventh grade ISCS students of 17 teachers located in two different localities (city and county).

The results showed that self-pacing produced higher learning rates and retention scores than deadlines. This was particularly true for low ability children.

The effect of working with a partner was different when measuring learning rate and retention, and was different for county and city children. There appears to be an advantage for low ability children who had deadlines in working with a partner. These children performed significantly higher on the retention test than low ability children with deadlines who worked alone.

The Problem

Teachers must make decisions on how much time to spend on certain educational objectives. In the conventional classroom, this decision is made by the teacher for the entire class and all students in that class are evaluated on the accomplishment of the objectives on the same day. In 1963, John Carroll proposed a model of learning which emphasized the

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idea of students accomplishing educational objectives at different rates.[1] Learning in which a student is expected to master a certain percentage of educational objectives became known as mastery learning. Benjamin Bloom[2] transformed the conceptual model of Carroll into an effective working model for mastery.

The ISCS program lends itself to mastery learning. Materials are written in a highly structured manner by giving the student directions for the experiments to perform, and by providing specific places in a workbook to record observations and answer questions about them. "Excursions" which consist of remedial work and enrichment exercises are included in the text. The student can work independently through the materials without specific directions from a teacher.

Students work in ISCS classrooms at different rates. Some students may be as much as ten chapters ahead of other students.[3] With no specific deadlines, it appears that many students procrastinate.

On the other hand, if deadlines are imposed, the teacher has a little more control of the situation and the deadline itself may give the student the impetus to work on the educational objectives. If the student does not complete the objectives during the assigned time, however, there may be detrimental effects due to insufficient learning of prerequisite skills needed for learning future chapters.

Most of the studies on rate of learning have been done with programmed instruction over short periods of time.[4-6] These may have little relation to what occurs in a classroom where a student may determine his own rate and where distractions abound. Others that have utilized classrooms for longer periods of time have shown conflicting results.[7-9]

In addition to the imposition of deadlines versus self-pacing, the effect of working by oneself or with a partner may affect the rate of

learning. While it could be argued that each student must work through the materials in order to fully understand them, it may be helpful to a student to be exposed to the problem solving and learning strategies of peers by working with a partner. However, social contact which could conceivably motivate the student to learn may, in fact, be a hindrance.

Again, research in the area of working with a partner versus working alone has not been conclusive. Most short term studies have shown that working with someone else is superior for problem solving and creativity.[10-13] Experiments of longer duration showing superiority of working with a partner have been performed by Goldschmidt[14] and Scott.[15] These, however, involved college students.

Teachers using self-pacing face a dilemma as to how students should proceed with the learning materials in order to learn at the most efficient rates. Thus the purpose of this study was to determine whether placing deadlines for completion of ISCS chapters and working with a partner would produce higher learning rates.

Procedures

Sample

The subjects of this study were 1022 seventh-grade ISCS students in 43 classrooms of ten Indiana schools. Four were county schools (four teachers) and six were city schools (eight teachers). Both school systems had adopted the ISCS program in grades seven and eight.

A stratified random sample of teachers to treatment was accomplished by grouping the 12 teachers into four groups of three each and randomly assigning a treatment to each of the four groups. Consideration of geographic locality (city or county), the socio-economic status (inner city or suburban) and teacher ability (determined by their students' success

on an ISCS unit test and the number of chapters they completed the previous school year) was made in grouping the teachers.

Instruments

The following instruments were used in the study.

1. Attitude Test. A Scale to Measure Attitude Toward Any School Subject used by permission of the Purdue Research Foundation.[16]

2. Mental Ability. Otis-Lennon Test of Mental Ability, Form J. This test was administered to the county students. Scores for city students were obtained from school administrators.

3. Chapter Tests. Three equivalent forms of criterion-referenced tests for chapters 1-4 were composed by the author. Items were keyed to performance objectives prepared by the ISCS staff at Florida State University. The final form of each test consisted of multiple choice items (three per objective), free response items and laboratory performance items. The validity and reliability of the tests were established during the 1972-1973 school year.

4. Unit Test. Two forms of the unit test were administered in the 1972-1973 school year to students of 16 teachers. These were revised for the 1973-1974 study.

Every objective from chapter one through four that was tested by multiple choice items was evaluated on this test. In order to restrict test length, five free response and two laboratory performance items were included. The Kuder-Richardson 20 coefficient for these two forms was 0.67 and 0.73 respectively. Although these should be equal for equivalent tests, because the tests were randomly distributed to students in all treatments, test equivalence was not an absolute necessity for the experiment.

Description of Treatment

One treatment consisted of working with a partner or alone. A student who was classified as working alone completed his or her own copy of the ISCS record book and worked with a partner only if a partner was necessary to manipulate the ISCS equipment. This involved no permanent partnership: the student found anyone available to help on a temporary basis. Students who were classified as partners completed a single ISCS record book. Both students received the same evaluation for this phase of their work. Partners also performed the experiments together and studied self-evaluations with each other. Partners engaged in self-pacing took the chapter test on the same day. If one partner passed the test and the other partner failed, the partner that passed acted as a tutor until both achieved mastery of the chapter.

A second treatment consisted of self-pacing or group-pacing. Students who were group-paced took each chapter test on a set date. The amount of time allowed for each chapter was determined by common agreement of the teachers based on their experience in teaching the chapter the previous year. There was a maximum and minimum amount of time specified for each chapter. Teachers were free to determine the amount of time needed within that time span. This allowed for different types of school schedules (double and single periods) and different types of school situations (suburban and inner city). Students who were group-paced were free to move at their own rate during the time span allowed for the chapter. If they finished the chapter ahead of time, they were free to study the content of the next chapter. If the students did not complete the chapter during the designated time, they nevertheless took the chapter test and began the next chapter the following day. This group is referred to as

having deadlines. Students who were self-paced took the chapter tests when they completed the chapter. If students did not accomplish the specified number of objectives, they were directed to restudy the material and take an alternate form of the test. If the test was failed a second time, a third opportunity was given. If the student failed the test three successive times, it was left to the teacher's discretion whether to require the student to continue studying the chapter or go on to the next. If one partner achieved mastery and the other did not, the student who passed the test helped the other student until both achieved mastery.

Data Treatment

The effect of pairing and pacing on learning rate was examined for low (below 93), average (93-105), and high (above 105) ability children. Use of this classification divided the sample into three groups of approximately the same size. Learning rate was defined as the number of objectives achieved per hour. It was calculated by dividing the number of objectives a student achieved on the test by the number of hours spent studying those objectives. (Absences, tardiness, school holidays, assembly periods, passing time and cleanup time were considered in determining the hours.)

The retention test was given immediately after students completed the first four chapters of the ISCS text. The attitude test was also administered at this time.

Partners were assigned within the first few days of the semester to form homogeneous (five points or less difference in mental ability scores) or heterogeneous (12 points or more difference in mental ability scores) pairs. One of the objectives of the study had been originally to examine the effect of different types of partnerships on learning rate. Data

were not analyzed in this manner for learning rate because a preliminary analysis showed no differences. Three levels of grouping (individuals, homogeneous partner, heterogeneous partner) were analyzed for differences in retention and attitude.

Learning rate data were examined by using repeated measures analyses and also analyzing data from each chapter separately. (The repeated measures analyses substituted zeros for missing data whereas missing data were excluded in the separate chapter analyses.) The latter were used as a check on the repeated measure analyses since data were not uniformly missing from all cells. Because results of both analyses were essentially the same, only the repeated measure analyses are reported in this paper.

Results

The effect of pacing and pairing on learning rate according to mental ability was examined by a repeated measures analysis of variance on learning rates over chapters two, three and four of the seventh grade ISCS text. The rate at which students learned chapter one was not examined because of the variety and irregularity in school schedules during the first days of the school year. Separate analyses of learning rates for the county and city were performed.

Learning Rates for County Students

Examination of Table 1 shows that pacing and pairing had a significant effect on learning rate. Levels of pacing and grouping were combined in order to utilize the EDSTAT AV2B1W computer program. Means for the different treatment groups may be seen in Figure 1.

Insert Table 1 Here

Insert Figure 1 Here

In order to determine whether pacing, pairing, or both had a significant effect on learning rates, means were compared using the Newman-Keuls procedure. The results indicated that students who worked alone had a higher learning rate than those with partners, and that there was no significant difference in learning rate whether students had deadlines or were self-paced. Analyses also showed that as mental ability increased so did rate.

Learning rate over the three chapters was significant beyond the 0.0001 level. This was expected because of the varying levels of difficulty of concepts contained in chapters of the text. Examination of the means by the Newman-Keuls analysis shows these to be significant.

Interaction effects for the analysis were significant as shown in Table 1. The trends in the data can be examined through the graphical representation shown in Figure 1. From the diagram it can be seen that there was virtually no difference in learning rate between students who worked as partners whether they had deadlines or were self-paced. Among students who worked alone, students who were self-paced worked at a faster rate for chapter two but this was generally reversed for later chapters.

Learning Rates for City Students

In the city the effect of the pairing-pacing treatment is also significant beyond the 0.0001 level as is shown in Table 2. Examination of the city means, however, shows a different effect than in the county. Newman-Keuls test of the means indicated that children who worked as partners learned at faster rates than those who worked alone.

Insert Table 2 Here

The effect of deadlines versus self-pacing on learning rate for city children was shown to be significant for students working alone. Those on self-pacing had higher rates. This was particularly true for low ability students and this same trend was present for average ability children. For high ability children deadlines appeared to be better for chapters three and four.

Comparison of the means of the learning rates of students of different mental ability show that these differences are significant for every chapter. As in the county schools, children's learning rates increased with mental ability.

The pairing-pacing-mental ability interaction across the chapters is shown in Figure 2. Examination of the graphs shows that low ability students worked at lowest rates when working alone with deadlines and best when working alone with self-pacing. For middle and high ability students, working with a partner produced higher learning rates. Deadlines had a slight advantage for average ability children and there were mixed results for high ability children.

Insert Figure 2 Here

Effects on Retention

Retention effects were measured using a 2 x 2 x 3 factorial design. There were two levels of mental ability (low--below 100, high--above 100) and three levels of grouping (individuals, homogeneous pairs, heterogeneous pairs). Two levels of mental ability were used instead of three in order to maintain sufficient cell size.

Table 3 shows a significant difference beyond the 0.0001 level favoring self-pacing over deadlines for city students. Although this effect is not statistically significant in the county, as shown in Table 4, examination of the cell means indicated a trend in this same direction. (Cell means are found in Gabel.)[17]

Insert Table 3 Here

Insert Table 4 Here

One explanation for the higher scores for the self-paced students is that some data were missing from the self-paced cells. The poorest self-paced students were not included in the means because these students did not proceed at a fast enough rate during the year to take the unit test by the beginning of March.

Considerable evidence indicates that the difference in retention scores was due to the treatment effect rather than to missing data. In the county where missing data were almost nonexistent, there was a trend favoring self-pacing. In order to examine the city data more carefully, an ex post facto analysis of the data using mental ability as a covariate was performed. The analysis indicated that there was a significant difference between retention for the deadline and self-paced students with self-pacing favored.

The effect on retention of working alone or with a partner was not significent in the city analysis. It was significant at the 0.05 level in the analysis of the county data. Children who worked with a partner had higher retention scores.

The interaction of mental ability and grouping was significant at the 0.02 level in the city. In all analyses the trend was identical for

low ability students. These students obtained higher scores when working with a partner than when they worked alone. This could be due to the effect of working with a partner of higher mental ability. Different effects for high ability students were seen in the city and in the county. In the county, there was no difference between working alone or with a partner while in the city, high ability children who worked alone scored higher on the test.

The three way interaction effect was significant at the 0.002 level in the city sample but was not significant in the county sample. Several inferences can be made from examination of the means. With deadlines, low mental ability students working as partners are more successful than when working alone. There is little difference for the average ability group; the high ability group did better working individually. All self-paced groups did better than groups with deadlines. There were virtually no differences in retention scores for self-paced students of the same mental ability whether students worked alone or with partners.

Effects on Attitude

Students' attitudes according to treatment were analyzed as the dependent variable in a three way analysis of variance. The factors analyzed were identical with those in the analysis of retention scores. Results of the analysis showed that all groups of students had a favorable attitude toward ISCS. Analysis of the separate school systems showed that the county students had a more favorable attitude toward ISCS than the city children. There was no significant difference between the attitudes of children who had studied ISCS with deadlines or self-pacing, or between students who worked alone or with partners.

Discussion

Learning Rate

The effect of requiring students to complete chapters by imposing deadlines did not consistently improve the rate of learning. The county and city analyses give different results in this regard. In the county, students of all mental abilities had faster rates for chapter two when they were self-paced and worked alone. However, this rate gradually decreased for low and average ability students on chapter three (increased for high ability students) and decreased for all students by chapter four. For chapters three and four, students working with a deadline and without a partner had either equal or better rates than self-paced students working alone. Students working with a partner in the county schools generally worked at slower rates whether they worked with deadlines or self-pacing. This last observation, plus the fact that the strongest two teachers in the county schools were ones whose students worked alone, suggests that this result is largely due to teacher effects. In the county schools where the average classroom size was about 25, students received much teacher encouragement and individual help. In addition, students appeared to be motivated by grades and parental pressure to do well. The mode of instruction here was probably not as important as in city schools.

The decrease in learning rate of self-paced students over chapters may lead one to wonder what the long range effects of self-pacing might be. This effect is fairly consistent for all ability groups in the county over chapters two, three, and four, and if it represents a trend that is likely to be continuous over the course of the school year, the merits of self-pacing would be called into serious question. However, the data presented in Table 2 show that this is not the trend in the city schools.

In the city a different effect on learning rate due to pairing and pacing was noted. For low ability students, self-pacing and working alone was generally favored although by chapter four, there was little difference in rate according to treatment with one exception. Low ability students working alone with deadlines consistently did poorer on all chapters. For average ability children, partners were favored. Students with deadlines began working at faster rates, but by chapter four, there was little difference in rates. This same trend was true for high ability children. As in the case of low ability children, average ability children working alone with deadlines had slower rates than for any other treatment.

One cannot help but wonder why there were differential effects for low, average, and high ability children. From observations of low ability children in ISCS classrooms and from conversations with their teachers the author inferred that these children were not motivated by grades. This suggests why these children achieved better with self-pacing. In the deadline classrooms, the low ability child apparently followed his usual routine of doing very little from day to day not caring what grade he received on the chapter test. He was probably used to achieving a low or failing grade. On the other hand, the child who was expected to master the material before he could proceed to the next chapter had some additional motivation--he did not want to be on the same chapter forever.

There is an additional factor here which is extremely important in the self-paced classroom and which could have led to superior learning rates for low ability students. In classrooms in which all children are proceeding together, the teacher is not as likely to identify children who are having difficulty with the subject matter. This is particularly

true when classes are large as they were in the city system. Children who are the most likely to receive attention are the aggressive or brighter children who need less attention than children with learning difficulties. On the other hand, in the self-paced classrooms children who were falling behind in their work were more likely to receive attention and encouragement. First of all, these children are easier to identify than the slower children in the "deadline" classroom, and secondly, the teacher is anxious to get them on to the next chapter. Classroom evidence for this increased interest on the part of the teacher were statements written on the students' papers such as "See me about this," and the moving of several students who were learning at slow rates to the same table so that the teacher could give them more extra help.

For average and high ability city children no general statement can be made concerning the effect of self-pacing and deadlines on learning rate. Students of average and high ability learn fastest with deadlines and partners and slowest with deadlines working alone. Apparently pacing makes no difference on learning rate but the effect of having a partner is significant. This increased social interaction for the average and high ability student may have led to faster learning rates.

Two other conclusions can be drawn about learning rate from this experiment. First, children of different ability learned at different rates with higher ability students learning faster. Secondly, the rate of learning varied from chapter to chapter. This result is quite likely due to the variation in the chapter content and the difficulty of the concepts in the chapters.

Retention

The effect of allowing students to pace themselves to meet a criterion level rather than work within the confines of a deadline

produced higher retention for low ability students in both county and city schools and for high ability students in the city. However, for high ability students in the county there was little difference in retention according to treatment.

For low ability students this finding is very important and even more significant when one realizes that the low ability "self-paced" student was retaining the material for a longer period of time than the "deadline" student. Because the test was given after chapter four, the low ability "deadline" student took this test approximately three months from the beginning of the school year. Many "self-paced" students did not take this test until January or February. Although it could be argued that that the "deadline" student did not have lower retention but that he did not learn the concepts in the first place, the point is that when the lower ability student did learn the materials in order to to pass the chapter tests, he was likely to retain these concepts over a relatively long period of time.

For high ability children there was no difference in retention in the county for the self-paced or deadline groups; however, self-pacing was favored in the city. Again, county children probably had pressure from parents and grades which motivated them regardless of the mode of instruction.

The effect of partners on retention generally had a positive effect. For low ability students in the city, those who worked with a partner had higher retention than those who worked alone with deadlines but they did not have higher retention than the self-paced group. In fact, all scores for the self-paced groups were practically identical for individuals and partners indicating that the partnerships had little effect on retention for city children.

In the county, the effect of low ability students having a partner was to produce higher retention scores. The author feels that this is an indication that partnerships increased retention for the following reasons. In the county, children working as partners were from schools where the teachers had lower ratings than where students worked alone. In the county there appeared to be greater control over the partnerships, that is, the teachers seemed to almost force students to work with their partner only and no one else. This was easier to do in the county than in the city because classes were smaller in size and because of the shorter part of the school year that county children took to complete the same number of chapters (class periods were longer). In addition, because classes were smaller, the teachers could see that both students were working and that the partnership did not consist of one worker and one observer.

Synthesis of Findings and Recommendations for Teaching

In general, the results of this study have shown that self-pacing in ISCS classrooms produced higher learning rates and retention scores than deadlines. This was particularly true for low ability children. Whether a teacher, school, or school system adopts a self-paced mode for ISCS instruction depends on the capabilities and willingness of the personnel and the objectives of science teaching in the junior high school. When students work with deadlines they are "covering" many more science concepts and are exposed to a wider diversity of skills than when they are self-paced and required to meet a criterion-level. However, the "self-paced" students are apparently learning the content of fewer chapters to a greater extent and are, therefore, learning more difficult concepts. If the objective of the junior high school science program is

to focus on these higher level concepts, then this is best achieved by allowing students to pace themselves and require mastery of one chapter before proceeding to the next. According to this research low ability students who were self-paced were learning at faster rates than students on deadlines but this may not be evident to the classroom observer. Since there is little difference in students' attitudes toward ISCS whether they have deadlines or self-pacing, self-pacing is to be preferred.

The effect of working with a partner is different when measuring learning rate and retention and is different for county and city children. If the teacher can control the partnership so that each student is working, there appears to be an advantage, particularly for low-ability children, in working with partners. Low ability students who worked with a partner did better on the retention test and retention is considered to be a more important educational objective than learning rate. In addition, because working with a partner requires less equipment than working alone, the cost of operating the ISCS program could be reduced by using this instructional mode.

In conclusion, there appears to be an advantage in allowing students to pace themselves while requiring them to reach a criterion level and to have them work with a partner. Both of these strategies make the students give more attention to the concepts which they are to learn and consequently enhance learning.

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TABLE 1

Analysis of Variance of Learning Rate
in County Schools

Between-Subjects Variance

Source	Mean Squares	Degrees of Freedom	F Ratio	P Level
PG (Pacing-Grouping)	5.39	3	11.40	.0000
A (Mental Ability)	37.02	2	78.24	.0000
PGA	1.26	6	2.67	.0150
Error (B)	.47	391		

Within-Subjects Variance

Source	Mean Squares	Degrees of Freedom	F Ratio	P Level
C (Chapter)	51.62	2	163.80	.0000
PGC	6.15	6	19.53	.0000
[illegible]	4.14	4	13.14	.0000
PGAC	.58	12	1.84	.0377
Error (W)	.32	782		

TABLE 2

Analysis of Variance of Learning Rate
in City Schools

Between-Subjects Variance

Source	Mean Squares	Degrees of Freedom	F Ratio	P Level
GP (Group-Pacing)	10.90	3	15.69	.0000
A (Mental Ability)	55.05	2	79.29	.0000
GPA	3.08	6	4.44	.0004
Error (B)	.69	585		

Within-Subjects Variance

Source	Mean Squares	Degrees of Freedom	F Ratio	P Level
C (Chapter)	37.35	2	79.55	.0000
GPC	.59	6	1.26	.2699
AC	2.56	4	5.46	.0004
GPAC	1.36	12	2.90	.0008
Error (W)	.47	1170		

TABLE 3

Analysis of Variance of Retention Scores in City Schools

Source	Mean Squares	Degrees of Freedom	F Ratio	Probability
Total	19.66	544		
Between	327.22	11		
P (Pacing)	978.81	1	73.55	.0000
A (Mental Ability)	2262.62	1	170.03	.0000
G (Grouping)	7.68	2	0.58	.5674
PA	17.24	1	1.30	.2541
PG	17.27	1	1.30	.2730
AG	54.83	2	4.12	.0165
PAG	90.61	2	6.81	.0016
Within	13.31	533		

TABLE 4

Analysis of Variance of Retention Scores in County Schools

Source	Mean Squares	Degrees of Freedom	F Ratio	Probability
Total	16.51	395		
Between	139.29	11		
P (Pacing)	15.45	1	1.19	.2755
A (Mental Ability)	50.06	1	103.94	.0000
G (Grouping)	49.22	2	3.79	.0228
PA	17.28	1	1.33	.2480
PG	13.34	2	1.03	.3602
AG	11.97	2	0.92	.5989
PAG	0.14	2	0.01	.9899
Within	12.99	384		

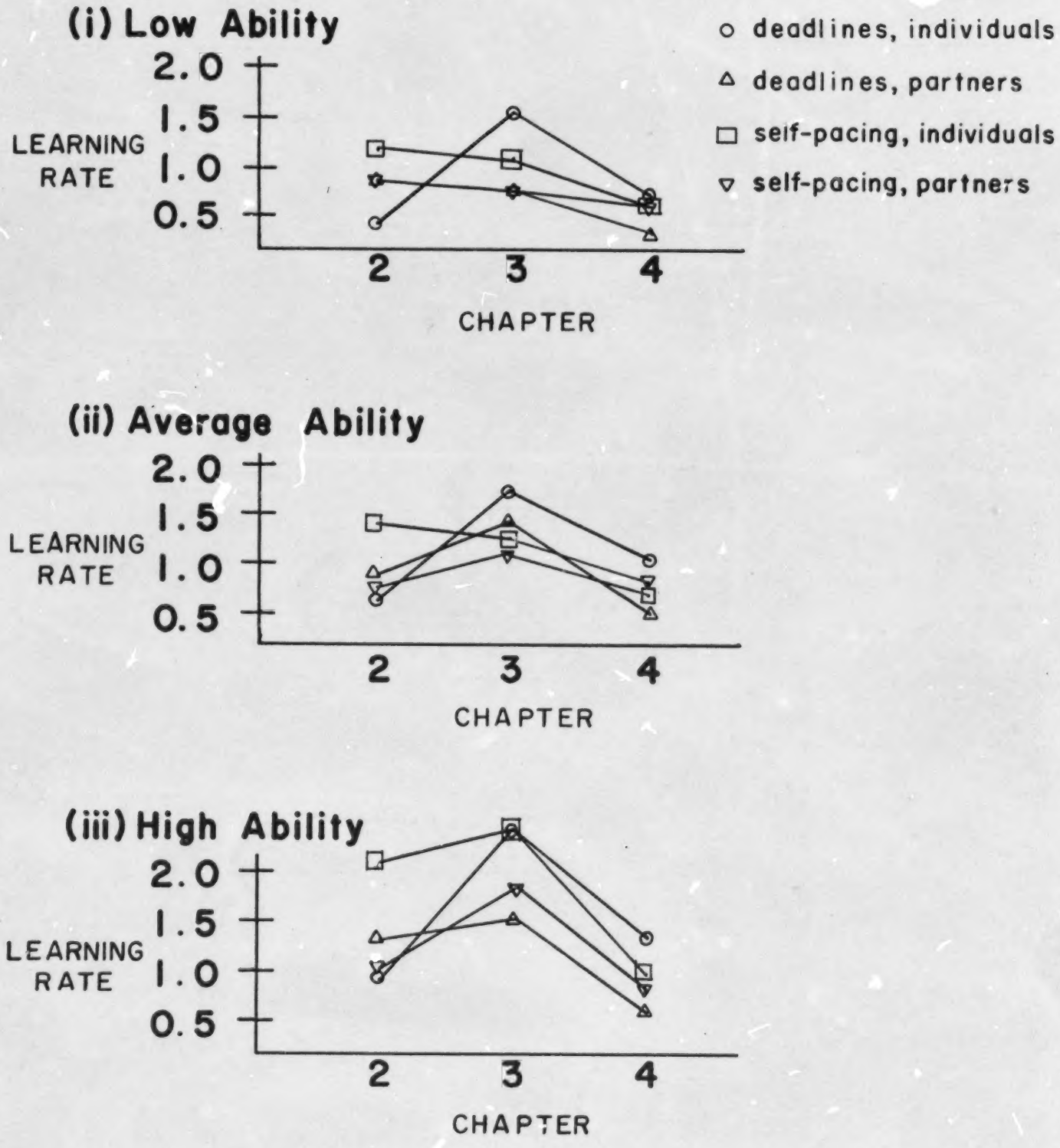

FIGURE 1

Mental Ability and Learning Rate Versus Chapters in County

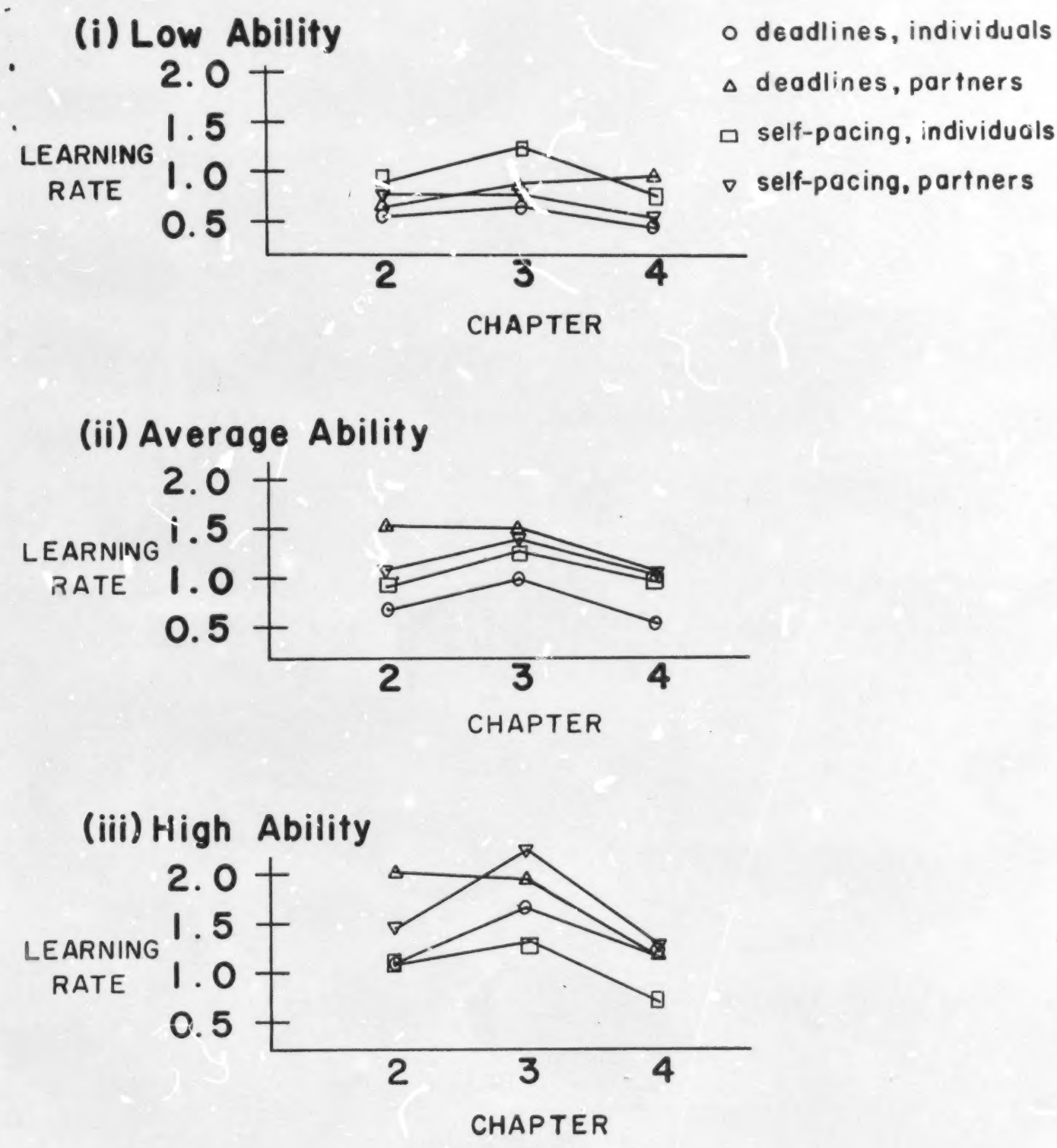

FIGURE 2

Mental Ability and Learning Rate Versus Chapters in City (Repeated Measures Analysis)